Assignment 1 due reminder

Good luck <3

Pointers Recap

- Used to store a memory address
- Can point to any type of data (int, struct, array)
- The data at the address can be accessed (dereference) `*`
- The address at a variable can be retrieved (address_of) `&`

Pointers syntax cheat sheet

- Declare a pointer: `int *int_pointer;`
- Address of: `&my_variable;`
- Dereference (Get the value at a pointer): `*int_pointer;`

Dynamic Arrays and Memory

The Stack

- Where information about your program execution is stored
  - Which functions are called, in what order
  - Which variables are created, and where

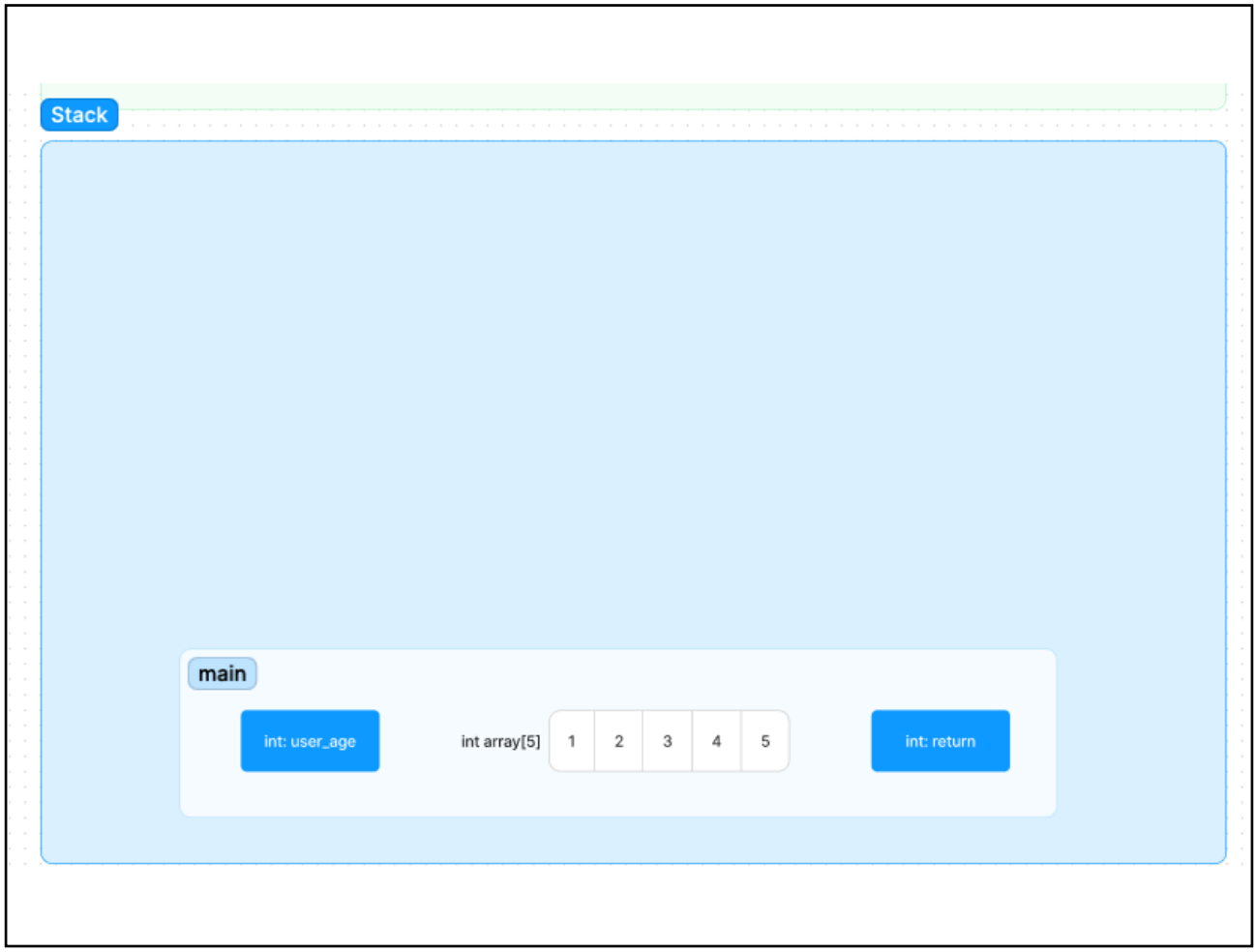
- When a block of code is executed `{ }`, a stack frame is created
- When the block is completed, the stack frame is removed (and anything inside it destroyed)

When a stack frame is created, enough memory to store everything in the frame is allocated to the frame

The Stack

```
int main(void) {
    int user_age = 20;
    int array[5] = {1, 2, 3, 4,
5};

    return 0;
}
```

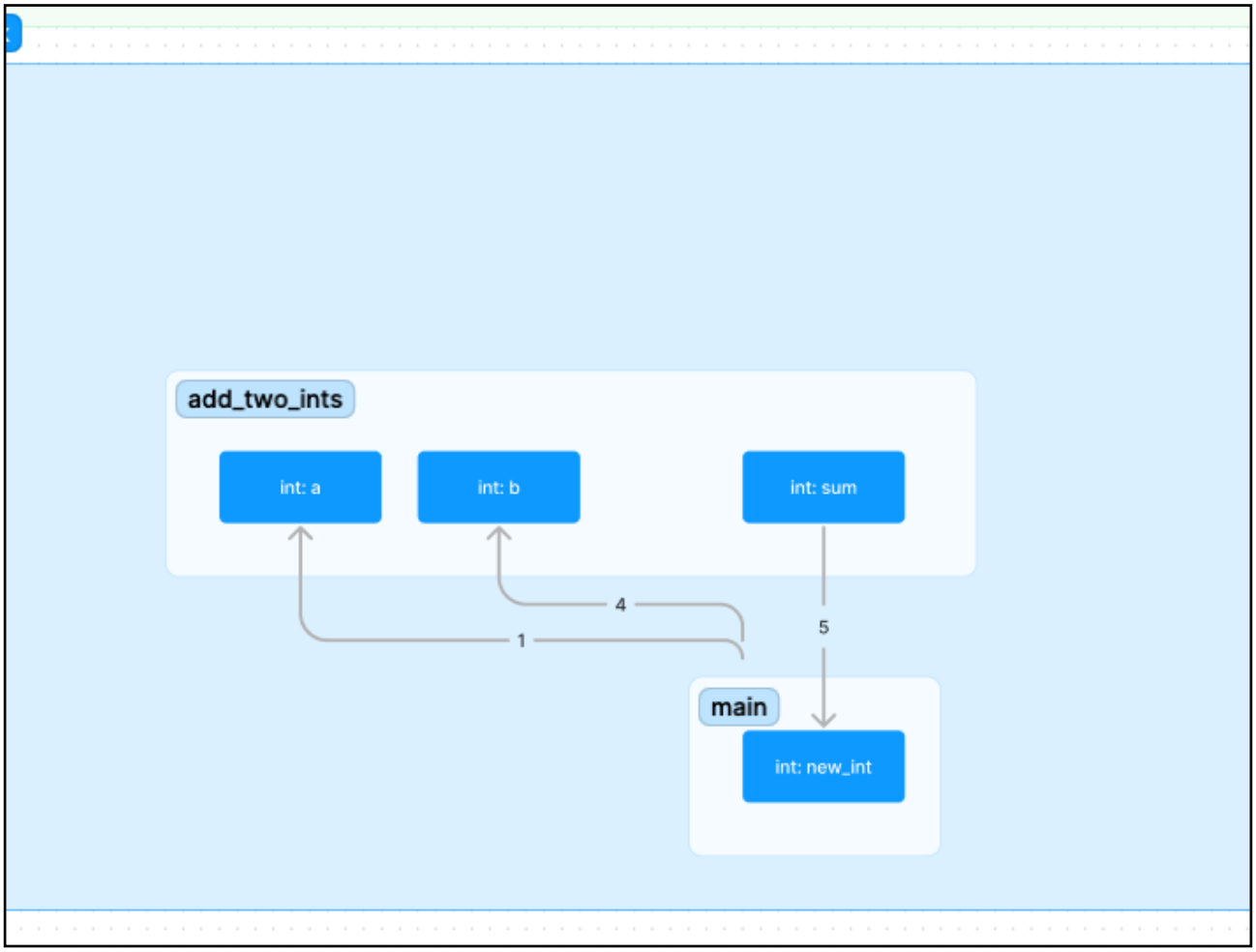

Stack
main
int: user_age
int array[5]
1
2
3
4
5
int: return

The Stack

```
int add_two_ints(int a, int b) {
    int sum = a + b;
    return sum;
}

int main(void) {
    int new_int = add_two_ints(1, 4);

    retrun 0;
}
```


add_two_ints
int: a
int: b
int: sum
4
1
5
main
int: new_int

Quick demo + whiteboard

What if we want to create memory with an undetermined size?

– We can't use stack frames... the program needs to know how big the frame is before it creates it

Enter: The Heap

- The Heap is a large block of memory that sits outside the stack
- Unlike the stack, the heap is managed entirely by the programmer (in C)
- Nothing is automatically declared or destroyed in the Heap, you have to manage it all! (This can be dangerous)
- *With great power, comes great responsibility*

Using the heap

C provides us some functions to interact with the heap.

`malloc()`

- `malloc` -> Memory Allocation (allocate memory on the heap)
- Returns a pointer to the location on the heap
- We can decide how large the allocation

Calling `malloc`

- `ptr = (cast-type*) malloc(byte-size)`

Example:

```c
#include <stdio.h>

int main(void) {
    malloc(1000);
    malloc(sizeof(int));
    malloc(sizeof(char) * 50);

    return 0;
}
```

Whiteboard

Dynamic arrays on the heap

A common way of using malloc is to create dynamic arrays:

```
int main(void) {
    int num_elements;
    scanf("%d", num_elements);

    int *data = malloc(num_elements *
sizeof(int));

    return 0;
}
```

Freeing malloc'd data

- This is where the responsibility comes in...
- C automatically frees stack frames after they finish, meaning we don't have to clean up after ourselves.
- We need to manually clean up the heap, otherwise we will cause a memory leak.

free

```
int *data = malloc(num_elements *
sizeof(int));
...
free(data);
```

`realloc`

- Either resizes the existing allocation (freeing what is no longer needed)
- Or allocates a new allocation
- Always returns the address of the new allocation, even if it's in the same position

realloc

```
int *data = malloc(num_elements *
sizeof(int));
num_elements += 40;

data = realloc(data, num_elements
* sizeof(int));
...
free(data);
```

Remember, we can treat pointers like arrays

Demo

Feedback

https://forms.office.com/r/K3PjvWebtD